I/WE CLAIM:

1   1.   A passive optical network (PON) with automatic ranging comprising;

2   an optical line terminal (OLT) connected to a plurality of optical network

3 units (ONUs);

4   a new ONU to be connected to the OLT;

5   at least one OLT frame sent from the OLT to the ONUs, the OLT frame

6 comprising:

7   an OLT preamble alerting a particular ONU of the plurality of ONUs of

8 the OLT frame;

9   an OLT start frame delimiter (SFD) indicating a start of the OLT frame;

10   an OLT header identifying the OLT;

11   an OLT ranging time stamp sending a ranging time clock to one of the

12 ONUs;

13   an OLT churning control for a churning function of the PON;

14   an ONU number instructing the particular ONU to respond to the OLT

15 with a ranging time stamp and a churning key; and

16   an OLT end frame delimiter (EFD) indicating an end of the OLT frame.

1   2.   The PON of claim 1 wherein, upon receipt of the OLT frame from the

2 OLT by the particular ONU of the plurality of ONUs, an ONU frame is sent back to the

3 OLT, the ONU frame comprising:

4   an ONU preamble alerting the OLT of the ONU frame;

5   an ONU start frame delimiter (SFD) indicating a start of the ONU frame;

6   an ONU header identifying the particular ONU;

7   an ONU ranging time stamp responding to the ONU number;

8   an ONU churning key responding to the ONU number; and

9   an ONU end frame delimiter (EFD) indicating an end of the ONU frame.

1   3.   The PON of claim 1, the ONU number further comprising:

2   an ONU number preamble alerting the particular ONU of the ONU

3 number;

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4		a start sub-frame delimiter (SSD) indicating a start of the ONU number;
5		an ONU ID identifying the particular ONU;
6		an automatic bandwidth adjustment beginning (ABAB); and
7		an automatic bandwidth adjustment terminating (ABAT).

1   4.   The PON of claim 1 further comprising an ONU frame for each of the

2 ONUs for returning to the OLT wherein the ONU frame comprises:

3   an ONU preamble alerting the OLT of the ONU frame;

4   an ONU start frame delimiter (SFD) indicating a start of the ONU frame;

5   an ONU header identifying the particular ONU;

6   an ONU ranging time stamp responding to the ONU number;

7   an ONU churning key responding to the ONU number; and

8   an ONU end frame delimiter (EFD) indicating an end of the ONU frame.

1   5.   The PON of claim 4, the ONU number further comprising:

2   an ONU number preamble alerting the particular ONU of the ONU

3 number;

4   a start sub-frame delimiter (SSD) indicating a start of the ONU number;

5   an ONU ID identifying the particular ONU;

6   an automatic bandwidth adjustment beginning (ABAB); and

7   an automatic bandwidth adjustment terminating (ABAT).

1   6.   A method for the PON of claim 5 comprising the steps of:

2   determining if the PON is a cold PON;

3   if the PON is a cold PON,

4   (a)   inputting the ONU ID into the OLT frame;

5   (b)   sending the OLT frame to each of the ONUs;

6   (c)   returning the respective ONU frame for each of the plurality ONUs

7 to the OLT if the ABAB in the ONU number is recognized;

8   (d)   calculating a round trip time for each of the ONUs in returning

9 their respective ONU frames to the OLT;

10   (e)   arranging the respective ONU frames for the plurality of ONUs in
11 a transmission sequence in accordance with the respective calculated round trip time for
12 each of the ONUs;

13   (f)   calculating a time difference for each group of two consecutive
14 ONU frames for the plurality of ONUs in the transmission sequence;

15   (g)   calculating an arrived time of the respective calculated round trip
16 time for each of the ONUs in the transmission sequence;

17   (h)   masking the time difference for each group of two consecutive
18 ONU frames for the plurality of ONUs in the transmission sequence into a result;

19   (i)   setting a time difference value for each group of two consecutive
20 ONU frames to its respective predetermined value if the masked result in the masking
21 step is less than or equal to the predetermined value;

22   (j)   setting the time difference value to a difference of the
23 predetermined value and the masked result if the masked result in the masking step is
24 greater than the predetermined value;

25   (k)   recalculating the ABAB and ABAT in the ONU number according
26 to the time difference value;

27   (l)   resending the OLT frame to each of the ONUs with the
28 recalculated ABAB and ABAT;

29   (m)   returning the respective ONU frame for each of the plurality ONUs
30 to the OLT in the transmission sequence if the recalculated ABAB in the ONU number is
31 recognized;

32   (n)   recalculating an arrived time of the respective calculated round trip
33 time for each of the ONUs in the transmission sequence, and respective begin time and
34 end time for the arrived time;

35   (o)   recalculating the time difference for each group of two consecutive
36 ONU frames for the plurality of ONUs in the transmission sequence;

37   (p)   determining if the recalculated time difference is greater than or
38 equal to a predetermined safety guard time.

1 7. The method of claim 6 further comprising the step of repeating the steps

2 (a), (b), (c), (d), (e), (f), (g), (h), (i), (j), (k), (l), (m), (n), (o) and (p) if it is determined in

3 step (p) that the recalculated time difference is not greater than or equal to the

4 predetermined safety guard time.

1 8. The method of claim 6 further comprising the steps of:

2   determining if there is more than one new ONU to be connected to the

3 OLT;

4   if it is determined there is more than one new ONU to be connected to the

5 OLT, repeating steps (a), (b), (c) and (d).

1 9. The method of claim 6 further comprising the steps of:

2   starting the returning step (c) if a double word (DW) count reaches the

3 ABAB;

4   stopping the returning step (c) if the DW count reaches the ABAT;

5   starting the returning step (m) if the DW count reaches the recalculated

6 ABAB; and

7   stopping the returning step (m) if the DW count reaches the recalculated

8 ABAT.

1 10. The method of claim 6 further comprising the steps of:

2   determining if the PON is a warm PON with cold ONUs;

3   if the PON is a warm PON with cold ONUs,

4   (1) stopping transmission of data frames of lower priority;

5   (2) resetting an offset value for the ABAB;

6   (3) inputting a parameter for a distance between the new ONU and the

7 OLT;

8   (4) rearranging the ABAB and the ABAT with the offset value;

9   (5) sending the OLT frame to each of the ONUs with the rearranged

10 ABAB and ABAT;

11   (6)   returning the respective ONU frame for each of the plurality ONUs

12   to the OLT if the ABAB in the ONU number is recognized;

13   (7)   calculating a round trip time for each of the ONUs, including the

14   new ONU, in returning their respective ONU frames to the OLT;

15   (8)   rearranging the respective ONU frames for the plurality of ONUs,

16   including the new ONU, in a new transmission sequence in accordance with the

17   respective calculated round trip time for each of the ONUs;

18   (9)   calculating a time difference for each group of two consecutive

19   ONU frames for the plurality of ONUs in the new transmission sequence;

20   (10)   calculating an arrived time of the respective calculated round trip

21   time for each of the ONUs in the new transmission sequence;

22   (11)   masking the time difference for each group of two consecutive

23   ONU frames for the plurality of ONUs in the new transmission sequence into a result;

24   (12)   setting a time difference value for each group of two consecutive

25   ONU frames to its respective predetermined value if the masked result in the masking

26   step is less than or equal to the predetermined value;

27   (13)   setting the time difference value to a difference of the

28   predetermined value and the masked result if the masked result in the masking step is

29   greater than the predetermined value;

30   (14)   recalculating the ABAB and ABAT in the ONU number according

31   to the time difference value;

32   (15)   resending the OLT frame to each of the ONUs with the

33   recalculated ABAB and ABAT;

34   (16)   returning the respective ONU frame for each of the plurality ONUs

35   to the OLT in the new transmission sequence if the recalculated ABAB in the ONU

36   number is recognized;

37   (17)   recalculating an arrived time of the respective calculated round trip

38   time for each of the ONUs in the new transmission sequence, and respective begin time

39   and end time for the arrived time;

40   (18)   recalculating the time difference for each group of two consecutive

41   ONU frames for the plurality of ONUs in the new transmission sequence;

42   (19)   determining if the recalculated time difference is greater than or

43   equal to a predetermined safety guard time.

1   11.   The method of claim 10 further comprising the step of repeating the steps

2   (1), (2), (3), (4), (5), (6), (7), (8), (9), (10), (11), (12), (13), (14), (15), (16), (17), (18) and

3   (19) if it is determined in step (19) that the recalculated time difference is not greater than

4   or equal to the predetermined safety guard time.

1   12.   A method for a passive optical network (PON) comprising a plurality of

2   optical network units (ONUs) and an optical line terminal (OLT), the method comprising

3   the steps of:

4   determining if the PON is a cold PON;

5   if the PON is a cold PON,

6   (20)   inputting an ONU ID into an OLT frame from the OLT;

7   (21)   sending the OLT frame to each of the ONUs;

8   (22)   returning a respective ONU frame for each of the plurality ONUs

9   to the OLT if an automatic bandwidth adjustment beginning (ABAB) in an ONU number

10   in the respective ONU frame is recognized;

11   (23)   calculating a round trip time for each of the ONUs in returning

12   their respective ONU frames to the OLT;

13   (24)   arranging the respective ONU frames for the plurality of ONUs in

14   a transmission sequence in accordance with the respective calculated round trip time for

15   each of the ONUs;

16   (25)   calculating a time difference for each group of two consecutive

17   ONU frames for the plurality of ONUs in the transmission sequence;

18   (26)   calculating an arrived time of the respective calculated round trip

19   time for each of the ONUs in the transmission sequence;

20   (27)   masking the time difference for each group of two consecutive

21   ONU frames for the plurality of ONUs in the transmission sequence into a result;

22   (28)   setting a time difference value for each group of two consecutive ONU frames to its respective predetermined value if the masked result in the masking step is less than or equal to the predetermined value;

(29)   setting the time difference value to a difference of the predetermined value and the masked result if the masked result in the masking step is greater than the predetermined value;

(30)   recalculating the ABAB and an automatic bandwidth adjustment terminating (ABAT) in the ONU number according to the time difference value;

(31)   resending the OLT frame to each of the ONUs with the recalculated ABAB and ABAT;

(32)   returning the respective ONU frame for each of the plurality ONUs to the OLT in the transmission sequence if the recalculated ABAB in the ONU number is recognized;

(33)   recalculating an arrived time of the respective calculated round trip time for each of the ONUs in the transmission sequence, and respective begin time and end time for the arrived time;

(34)   recalculating the time difference for each group of two consecutive ONU frames for the plurality of ONUs in the transmission sequence;

(35)   determining if the recalculated time difference is greater than or equal to a predetermined safety guard time.

13.   The method of claim 12 further comprising the step of repeating the steps (20), (21), (22), (23), (24), (25), (26), (27), (28), (29), (30), (31), (32), (33), (34) and (35) if it is determined in step (35) that the recalculated time difference is not greater than or equal to the predetermined safety guard time.

14.   The method of claim 12 further comprising the steps of:

determining if there is more than one new ONU to be connected to the OLT;

if it is determined there is more than one new ONU to be connected to the OLT, repeating steps (20), (21), (22) and (23).

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1   15.   The method of claim 12 further comprising the steps of:

2   starting the returning step (22) if a double word (DW) count reaches the

3 ABAB;

4   stopping the returning step (22) if the DW count reaches the ABAT;

5   starting the returning step (32) if the DW count reaches the recalculated

6 ABAB; and

7   stopping the returning step (32) if the DW count reaches the recalculated

8 ABAT.

1   16.   The method of claim 12 further comprising the steps of:

2   determining if the PON is a warm PON with cold ONUs;

3   if the PON is a warm PON with cold ONUs,

4   (36)   stopping transmission of data frames of lower priority;

5   (37)   resetting an offset value for the ABAB;

6   (38)   inputting a parameter for a distance between the new ONU and the

7 OLT;

8   (39)   rearranging the ABAB and the ABAT with the offset value;

9   (40)   sending the OLT frame to each of the ONUs with the rearranged

10 ABAB and ABAT;

11   (41)   returning the respective ONU frame for each of the plurality ONUs

12 to the OLT if the ABAB in the ONU number is recognized;

13   (42)   calculating a round trip time for each of the ONUs, including the

14 new ONU, in returning their respective ONU frames to the OLT;

15   (43)   rearranging the respective ONU frames for the plurality of ONUs,

16 including the new ONU, in a new transmission sequence in accordance with the

17 respective calculated round trip time for each of the ONUs;

18   (44)   calculating a time difference for each group of two consecutive

19 ONU frames for the plurality of ONUs in the new transmission sequence;

20   (45)   calculating an arrived time of the respective calculated round trip

21 time for each of the ONUs in the new transmission sequence;

22   (46)   masking the time difference for each group of two consecutive ONU frames for the plurality of ONUs in the new transmission sequence into a result;

24   (47)   setting a time difference value for each group of two consecutive ONU frames to its respective predetermined value if the masked result in the masking step is less than or equal to the predetermined value;

27   (48)   setting the time difference value to a difference of the predetermined value and the masked result if the masked result in the masking step is greater than the predetermined value;

30   (49)   recalculating the ABAB and ABAT in the ONU number according to the time difference value;

32   (50)   resending the OLT frame to each of the ONUs with the recalculated ABAB and ABAT;

34   (51)   returning the respective ONU frame for each of the plurality ONUs to the OLT in the new transmission sequence if the recalculated ABAB in the ONU number is recognized;

37   (52)   recalculating an arrived time of the respective calculated round trip time for each of the ONUs in the new transmission sequence, and respective begin time and end time for the arrived time;

40   (53)   recalculating the time difference for each group of two consecutive ONU frames for the plurality of ONUs in the new transmission sequence;

42   (54)   determining if the recalculated time difference is greater than or equal to a predetermined safety guard time.

1   17.   The method of claim 16 further comprising the step of repeating the steps (36), (37), (38), (39), (40), (41), (42), (43), (44), (45), (46), (47), (48), (49), (50), (51), (52), (53) and (54) if it is determined in step (54) that the recalculated time difference is not greater than or equal to the predetermined safety guard time.

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